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THE HAMILTON IN OHIO[1]

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At the beginning of the deposition of the Devonian formations belonging to the upper part of the Ulsterian and early Erian series, much of Ohio lay beneath a great inland sea. The island caused by the Cincinnati geanticline, and covering parts of Ohio, Indiana, and Kentucky, according to Ulrich and Schuchert,[2] probably became connected with the mainland to the southeast sometime during the Upper Silurian period, thus constituting it a peninsula of Appalachia. This condition probably continued until late in the Onondaga age, when the Cincinnati area once more became an island.

The Cincinnati peninsula may have extended as far north as the mouth of the Detroit River, the northern limit of the Silurian outcrop; but in this there is an element of uncertainty, since preglacial and glacial erosion might have removed the Devonian formations which may have covered the northern end of this tongue of land. But whatever the extent of this island or peninsula, the sea which surrounded it, wholly or in part, was continuous over a large part of the southern peninsula of Michigan, portions of Ontario, New York, and Pennsylvania, as well as Kentucky, Tennessee, Indiana, and Illinois.

By the beginning of the Hamilton—that is, the Erian epoch—great changes had occurred. The small gulf in eastern Ohio had expanded into the Cumberland basin, the Cincinnati island was again free from the mainland, and the Traverse strait formed a means of communication between the Dakota and Mississippian seas; but the Kankakee peninsula still formed an effective barrier between this western sea and the Indiana basin of the Mississippian.[3] In other words, a great period of sea encroachment had set in which affected mainly the northwestern coast of Appalachia and the land area beyond the Indiana basin. Ohio therefore lay beneath the same sea, much enlarged since the earlier Devonian, as that covering the southern portion of New York in Hamilton time, and naturally contains deposits contemporaneous with those of New York.

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[1] A paper read before the Biological Club of the Ohio State University, February 4, 1907. The work on this subject was done while a graduate student at the university (1905–6), and during the succeeding summer; hence it contains many of the ideas and suggestions of Professor Prosser.

[2] *New York State Museum Bulletin No. 52* (1901), p. 648.

[3] Schuchert, *American Geologist*, Vol. XXXII, pp. 143–62, and Plates XX, XXI.

As at present defined, the Devonian system in Ohio comprises the following formations:[1]

4. Ohio shale
   - *c*) Cleveland shale
   - *b*) Chagrin formation
   - *a*) Huron shale
3. Olentangy shale
2. Delaware limestone
1. Columbus limestone

The Columbus limestone is the southern extension of the Dundee of Michigan and the eastern extension of the Jeffersonville of Indiana and Kentucky. This equivalence is shown, not only by lithological similarity and stratigraphic identity, but conclusively by the faunal unity. These Indiana, Michigan, and Ohio limestones are but the local representatives of the Onondaga of New York, or, if we accept the conclusion of Ulrich and Schuchert,[2] which is also supported by Dr. J. M. Clarke,[3] that the Onondaga fauna invaded the state from the west, perhaps it is better to say that the Onondaga limestone is but the New York representative of these limestones.

But what of the Delaware limestone? Newberry and Orton included it with the Columbus as the Ohio equivalent of the "Corniferous" (Onondaga).[4] This, however, seems to have resulted mainly from a mistaken correlation of the deposits occurring in the eastern part of Sandusky,[5] where the upper layers of the Columbus limestone show some variation, both lithological and faunal, from that of the vicinity of the city of Columbus, and approach somewhat the appearance of the true Delaware. Professor Winchell, however, having made an extensive study of these outcrops over the state, pronounced them of Hamilton age.[1] Dr. Newberry agreed that the Olentangy shale, or at least the deposit immediately overlying his "Corniferous" in the northern part of this state, may be Hamilton,[2] and this was evidently supported by the fauna of the Prout limestone, a thin fossiliferous layer occurring immediately below the Huron shale in northern Ohio, but he strenuously objected to the correlation of the Delaware with the Hamilton of the east.[3]

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[1] Prosser, *Report of the Geological Survey of Ohio*, Fourth Series, Bulletin No. 7, p. 3.

[2] *Loc. cit.*, pp. 652, 653, 663.

[3] *Ibid.*, pp. 667, 668.

[4] *Report of the Geological Survey of Ohio*, Vol. I, Part 1, pp. 144, 150, 151; Vol. II, Part 1, pp. 190–92, also 290, 3d note; Vol. III, p. 606.

[5] Prosser, *Journal of Geology*, Vol. XIII, No. 5 (1905), pp. 439–42.

Some time later (1878) Dr. Whitfield visited central Ohio and discovered the brown shale carrying a Marcellus fauna at the base of the Delaware. This, he says, forms "a dividing line between the lower and upper Devonian, as between the limestones of the Upper Helderberg and those that properly refer to the Hamilton period."[4]

Again referring to Ulrich, Schuchert, and Clark, we find that the Marcellus shale fauna very likely entered southeastern New York from the Atlantic, and thence spread westward.[5] Deposits of unquestioned Onondaga in western New York are in all probability contemporaneous with true Marcellus deposits in the eastern part of the same state.[6] This may also be true of the upper part of the Columbus limestone, but the finding of Marcellus deposits in this vicinity (Columbus), even though meager, proves that "the invasion of the black muds which produced the Marcellus beds, and with these the diminutive fauna characteristic of these beds," reached as far west as central Ohio, and hence marks an epoch of change which cannot easily be overlooked. By the time this Marcellus invasion had reached the eastern shore of the Cincinnati island its impetus seems to have been nearly exhausted, as the brown, shaly portion of the Delaware measures but 6 feet and does not occur at all in Indiana, nor does it appear to be recognized in Michigan.

About this time the Hamilton invasion began. The species characteristic of this fauna, Dr. Clarke tells us,[1] invaded New York from the west, part coming up through the Indiana basin and another part through the Traverse strait from the Dakota sea, but the great majority of the species were probably developed from the Onondaga fauna of the northwestern Mississippian sea. Professor Schuchert thinks that the Connecticut channel still continued to admit a few European species during the Hamilton time,[2] but Dr. Grabau says that its efficiency "was greatly diminished."[3] We thus see the heterogeneous character of the Hamilton fauna, which is most marked in regions, such as Ontario and western New York; where all of these elements blended, and thus an excuse, in more isolated regions, for great variation even in true faunas of this age.

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[1] *Report of the Geological Survey of Ohio,* Vol. II, Part 1, pp. 244, 289–94, 338, 339, 426, 427, etc.

[2] *Ibid.,* pp. 189, 190.

[3] *Ibid.,* Vol. 1, Part 1, p. 144; Vol. II, Part 1, p. 290.

[4] *Proceedings of the American Association for the Advancement of Science,* Vol. XXVIII (1880), p. 298.

[5] *Loc. cit.,* pp. 665, 668.

[6] Grabau, *New York State Museum Bulletin No. 92,* p. 231.

Following the base of the Delaware northward, it soon loses its shaly character, and yet even at Stratford, 20 miles north of Columbus, blocks of the massive blue layers from this horizon split into thin, somewhat shaly fragments after extensive weathering, and still contain the same fauna characteristic of these beds in Franklin County. Above the 6-foot shaly zone occur 30 feet of blue limestones, varying from thin-bedded to massive, and sometimes, as at Delaware and Owen, having bands of soft, blue shale from a few inches to a foot in thickness, at different horizons. In Franklin County the formation contains much black chert, which usually occurs as layers alternating with limestone, or sometimes taking the nature of zones; but northward the amount of this material decreases, until at Sandusky little or none occurs. In studying this formation and its fauna, it appears to me that this physical feature has been an influential factor in classifying this deposit among the "Corniferous" rocks. There is little in the lithological appearance of this formation, it is true, which suggests the soft, blue shales of the Eighteen Mile Creek outcrops, except perhaps its persistent blue color; but, on the other hand, the Hamilton deposits of Indiana and Michigan are mainly limestones. It appears, then, that the distinction must rest on the faunal evidence which may be extracted from the various outcrops.

The important outcrops of this formation follow the eastern and northwestern shores of the Cincinnati island. Taking up first the eastern shore, some forty outcrops of the Columbus have been visited and from these a total of nearly 175 distinct species have been collected, and many more reported by other collectors. The Columbus sea, in other words, was a veritable aquarium in which flourished one of the richest faunas that geological history records. Twenty-five sections, in which the Delaware limestone outcrops, have been examined, and from these a fauna of 71 species has been obtained. Among these we find the following relation: 25 Hamilton species; 16 "Corniferous"-Hamilton species; 13 "Corniferous" species, of which perhaps 3 were originally described from the Delaware and at least do not occur in the Columbus limestone; 17 species (mainly *Corals* and *Bryozoa*) unidentified. Among the Hamilton species are such as, *Lingula ligea* Hall, *Camarotœchia prolifica* Hall, *Ambocœlia umbonata* (Conrad), *Camrotœchia sappho* Hall, *Spirifer audaculus macronotus* Hall, *Chonetes scitulus* Hall, *Glyptodesma erectum* Conrad, *Nyassa arguta* Hall, *Grammysia bisulcata* (Conrad), *Sphenotus cuneatus* (Conrad)—a collection of species which is hard to bring into the "Corniferous" (Onondaga) category.

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[1] *New York State Museum Bulletin No. 52*, p. 669.

[2] Schuchert, *American Geologist*, Vol. XXXII, p. 162.

[3] Grabau, *New York Museum Bulletin No. 92*, p. 233.

In northwestern Ohio the evidence is even stronger. Here the rocks rise very little above drainage level, hence a good section is hard to obtain, but along Ten Mile Creek and Auglaize River, at opposite ends of the line of outcrop, fair sections may be found. These two agree in all essentials, both lithologically and paleontologically. Of the 27 feet, all quite fossiliferous, exposed along Ten Mile Creek, the lower 6 feet are soft, blue shales or shaly limestones, followed by 11 feet of soft and compact, blue to drab limestone, with a considerable amount of white chert, and capped by 10 feet of massive, compact, drab limestone. This section compares favorably with that of the Traverse of Michigan; in fact, it is but a continuation of the outcrops of that formation in Monroe County.

Fifty-nine species were collected from this locality and range as follows: 33 Hamilton species; 10 "Corniferous"-Hamilton species; 6 "Corniferous" species; 10 species unindentified. Among the fossils from this section are the following characteristic Hamilton species: *Favosites hamiltoniae* Hall, *Favosites nitella* Winchell, *Heliophyllum halli* Edwards and Haime, *Strombodes alpenensis* Rominger, *Chonetes scitulus* Hall, *Spirifer pennatus* (Atwater), *Leiorhynchus laura* (Billings), *Pleurotomaria sulcomarginata* (Conrad), *Tentaculites bellulus* Hall, *Phacops rana* (Green).

No argument is sufficiently strong to place such a collection of species on the Onondaga list. It is, in fact, a true Hamilton fauna.

How much of southeastern Ohio may contain Marcellus deposits, or to what extent, we do not know, but it is certain that the eastern shore of the Cincinnati island felt the effects of the changed conditions which this invasion brought about, while Franklin and Delaware Counties have recorded a trace of the black muds which these swampy seas have left. The impoverished and diminutive fauna which we find in the base of the Delaware proves that the luxuriant life which flourished during the Columbus stage was all but blotted out, and when more favorable conditions were restored, approaching, although never reaching, those which had previously existed, it was not the same fauna that took possession, but one composed of the few surviving Columbus species and a new lot probably wandering south from the hoards which were invading New York at this time. On the northwest coast of the island, however, conditions were different. It is probable that the Marcellus invasion never reached this point, but that the change from the Columbus to the Delaware fauna was gradual. Unfortunately the outcrops visited did not show the contact of these two formations, but the upper part of the Columbus in the sections of that part of the state shows evidence of a marked change in the fauna, which, by the time the shale-forming conditions of the Ten Mile Creek section had set in, had reached a complete conversion into that of the Traverse-Hamilton. To a certain extent the same is true at Sandusky, where these changes in progress in the upper part of the Columbus misled even Dr. Newberry and caused him to call it Delaware. The difference between the Delaware outcrops in the northwestern and central parts of the state may be accounted for in part by supposing, what seems to have been the case, that a spur or peninsula from the Cincinnati island extended as far northward, perhaps, as the present Canadian shore of Lake Erie, thus forming a more or less effective barrier against the fauna which was crowding eastward, and that in this somewhat protected central part of the state the Hamilton invasion was less intense, and thus the few remaining "Corniferous" species were better able to survive.

Gathering all of the available evidence, there seems to be no substantial support for any other conclusion than that the base of the Delaware marks the beginning of the Hamilton period in Ohio.

Whether the Olentangy shale also belongs to the Hamilton or Erian period, or how much of the deposits above the Delaware limestone belong to that age, is beyond the intentions of this paper. There are some reasons for believing that this shale should rather be classed with the succeeding formation, since other bands of a very similar if not identical, lithological nature occur within what is considered the Ohio shale. It seems certain, however, that Dr. Newberry's Prout Station section is Hamilton.[1] If this be the northern equivalent of the Olentangy shale, as is very generally supposed, there can be no further question as to its age, and the total thickness of the Hamilton in central Ohio is then at least 60 feet.

In the northwestern part of the state the Olentangy shale is apparently wanting, so that the limestones and shales (Traverse) succeeding the Columbus limestone probably represent both the Delaware limestone and the Olentangy shale in that section. The relations existing between these deposits in Ohio, Michigan, and New York may then be stated somewhat as follows:

Michigan	Ohio	New York
Traverse group	Olentangy shale Delaware limestone	Hamilton beds Marcellus shale
Dundee limestone	Columbus limestone	Onondaga limestone

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[1] *Report of the Geological Survey of Ohio,* Vol. II, Part I, p. 188.